THE INITIAL MASS FUNCTION AND STAR FORMATION LAW IN THE OUTER DISK OF NGC 2915

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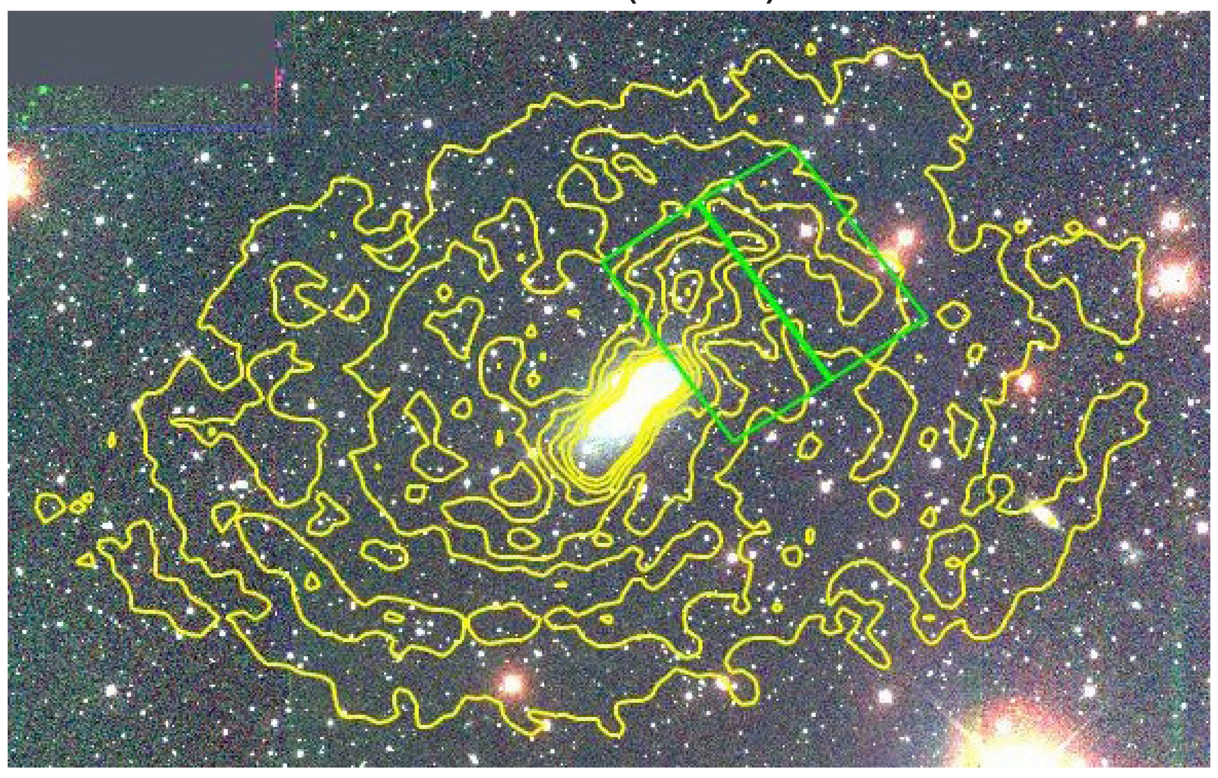
MOTIVATION

Star formation in the outer disks of gas-dominated galaxies is poorly understood. We determine the upper-end initial mass function (IMF) and star formation law (SFL) in an outer-disk region of NGC 2915; a blue compact dwarf galaxy with an extended HI disk (see Fig. 1). We study this region because of its high mass-to-light ratio, low stellar-density and extremely low-intensity star formation, making it an ideal target for understanding the IMF and SFL at the low density limit. For more details see Bruzzese et al. (2014).

Figure 1: Three colour IRV-band image of NGC 2915 (CTIO 1.5 m). The HST ACS/WFC footprint covering the outer disk is shown in green. HI mass surface density contours from Elson et al. (2010) are shown in yellow.



STELLAR CONTENT

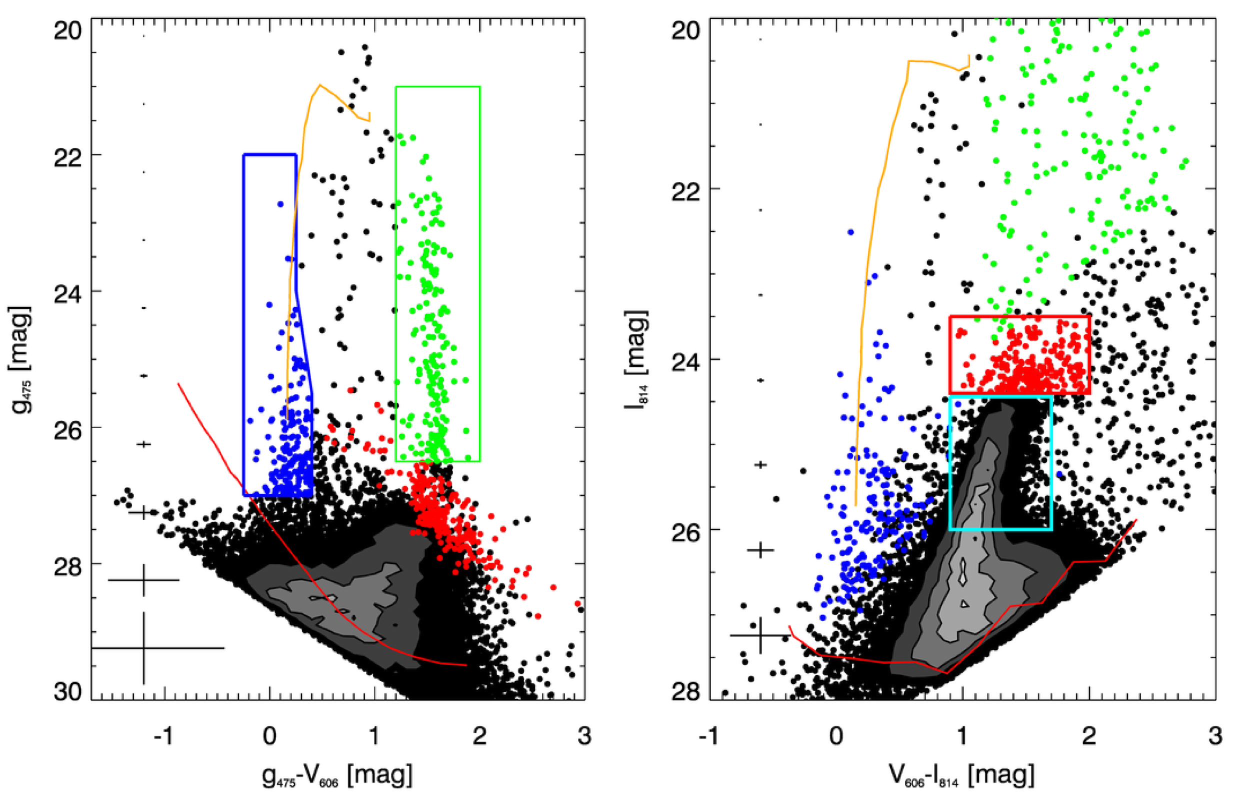


Figure 2: HST ACS/WFC colour magnitude diagrams (CMDs) of the outer disk region of NGC 2915. Polygons identify different stellar evolutionary phases. Blue: Main-sequence stars (left); Cyan: red giant branch (RGB) stars (right); Red: asymptotic giant branch (AGB) stars (right). The 60% completeness limit is shown as the red line. The Geneva evolutionary track for a 25 $M_{\odot}$ star is shown in orange.

IMF CONSTRAINTS

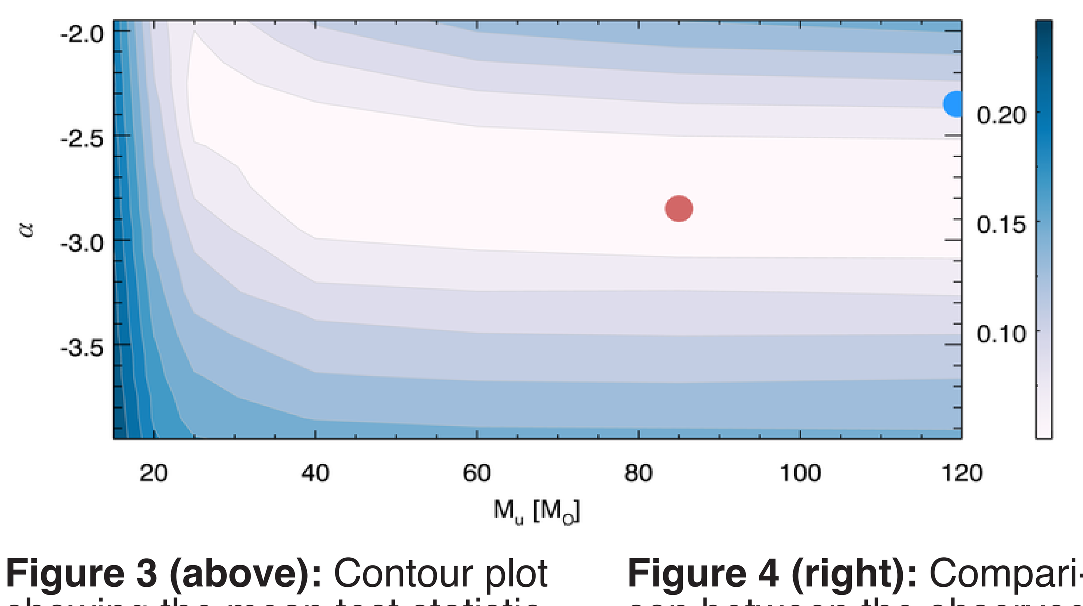
We determine the IMF in the outer disk of NGC 2915 by comparing the observed main-sequence luminosity function (see Fig. 2) to simulations.

Simulation method:

- Produce ensembles of 100 simulations, for each set of upper-end IMF slopes (α) and upper-mass limits (M_u)
- Use the Geneva evolutionary tracks with Z=0.008 (Schaerer et al. 1993) and E(V-B)=0.45
- A constant star formation rate over 200 Myr, justified by the isolation and quiescent nature of the outer disk

The K-S test is used to determine how well the observed data match simulations and determine the best-fitting IMF.

We find the IMF in the outer disk to be deficient in high-mass stars compared to a Kroupa IMF
$\alpha = -2.85$, $M_u = 85\ M_{\odot}$



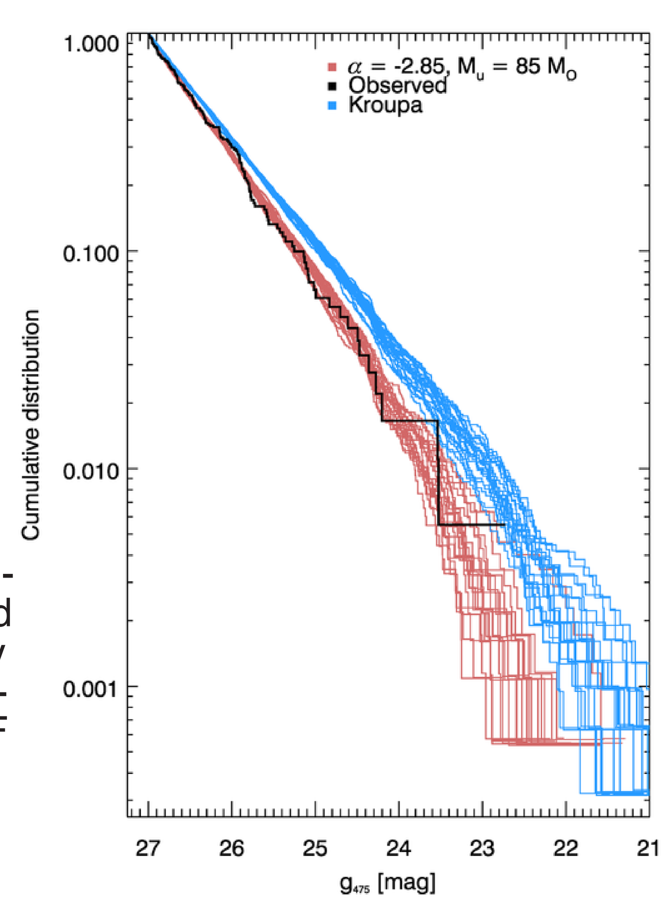


Figure 3 (above): Contour plot showing the mean test statistic D as a function of IMF slope (α) and upper-mass limit (M_u). The red point shows the best-fitting IMF (α = -2.85, M_u = 85 $M_{\odot}$). The blue point shows a Kroupa (2001) IMF for comparison.

Figure 4 (right): Comparison between the observed main-sequence luminosity function (black) and 20 realizations of a Kroupa IMF (blue) and our best-fitting IMF (red).

UPPER-MASS LIMIT CONSTRAINTS

We use previously published Hα observations by Werk et al. (2010) of a HII region in the ACS field to place further constraints on the upper-mass limit (M_u). We use the same set of simulations to determine the ionising flux produced for each main-sequence star via its initial mass and Table 3.1 in Conti et al. (2008). We then normalise the total Hα flux by the total V-band flux to create a pseudo Hα width for each simulation, which we compare to observations (see Fig. 5).

If we assume that all of the Hα is confined to HII regions then the upper-mass limit is restricted to $M_u < 20\ M_{\odot}$

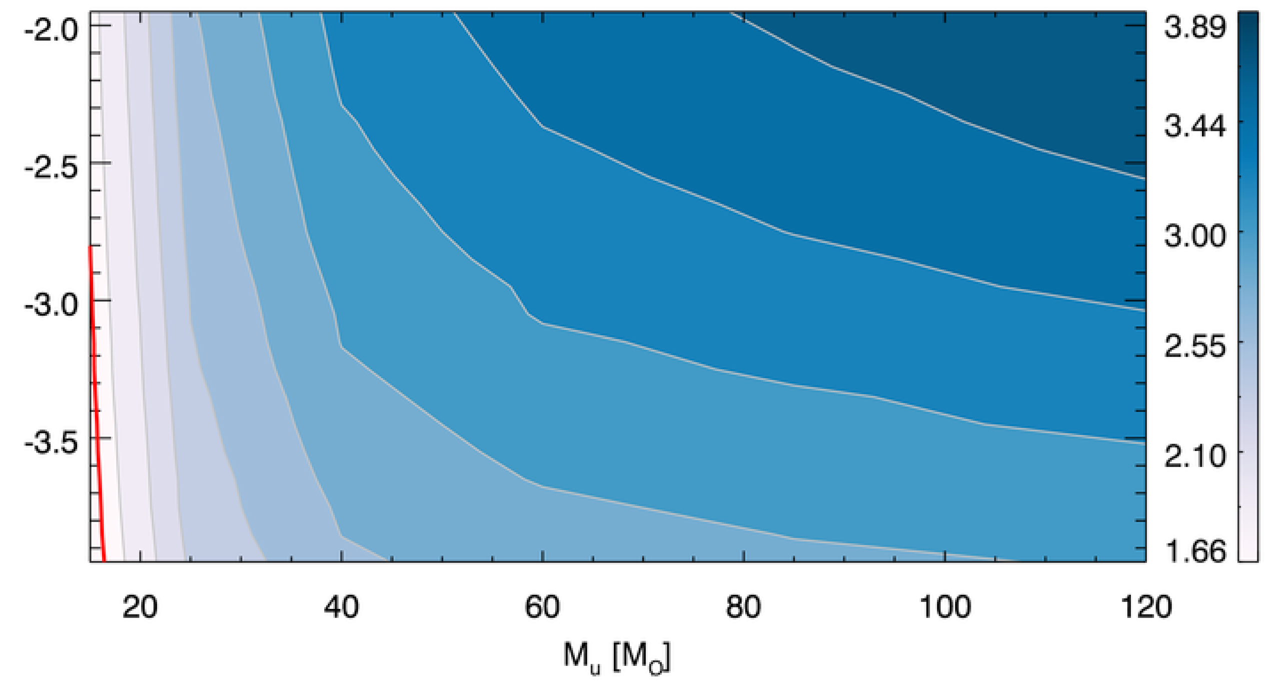


Figure 5: Contour plot showing the log of the average pseudo Hα equivalent width of the simulations as a function of IMF parameters. The observed Hα equivalent width (14Å < $w_{H\alpha}$ < 56Å) is identified by the red contour. On average M_u < 15 $M_{\odot}$ and restricts M_u < 20 $M_{\odot}$.

DICHOTOMY BETWEEN Hα & CMD

There is a mismatch between the CMD and Hα observations. The observed CMD (Fig. 2) implies multiple high mass stars capable of ionising the ISM. Yet the observed Hα emission from the HII region requires a single O star with M~19 $M_{\odot}$.

Possible resolutions:

1. Total Hα emission is not confined to HII regions and some of the ionising radiation is escaping the system or forming undetected diffuse ionised gas.
2. Total Hα emission is confined to HII regions and the high-luminosity blue objects in the CMD are binaries or compact clusters of lower mass stars. In this case the IMF is even more deficient in high-mass stars.

STAR FORMATION LAW

The position of the young main-sequence stars with respect to the HI gas provides a means to examine the SFL in the outer disk. The main-sequence stars have a clumpy distribution that follows the HI gas (Fig. 6). We use the same set of simulations to determine the star formation rate from the surface density of main-sequence stars, for a Kroupa IMF.

$$\Sigma_{SFR} = A\,\Sigma_{HI}^{N}$$

We find N = 1.53 ± 0.21 and
A = 9.60 ± 3.35 x $10^{-6}\ M_{\odot}yr^{-1}kpc^{-2}$

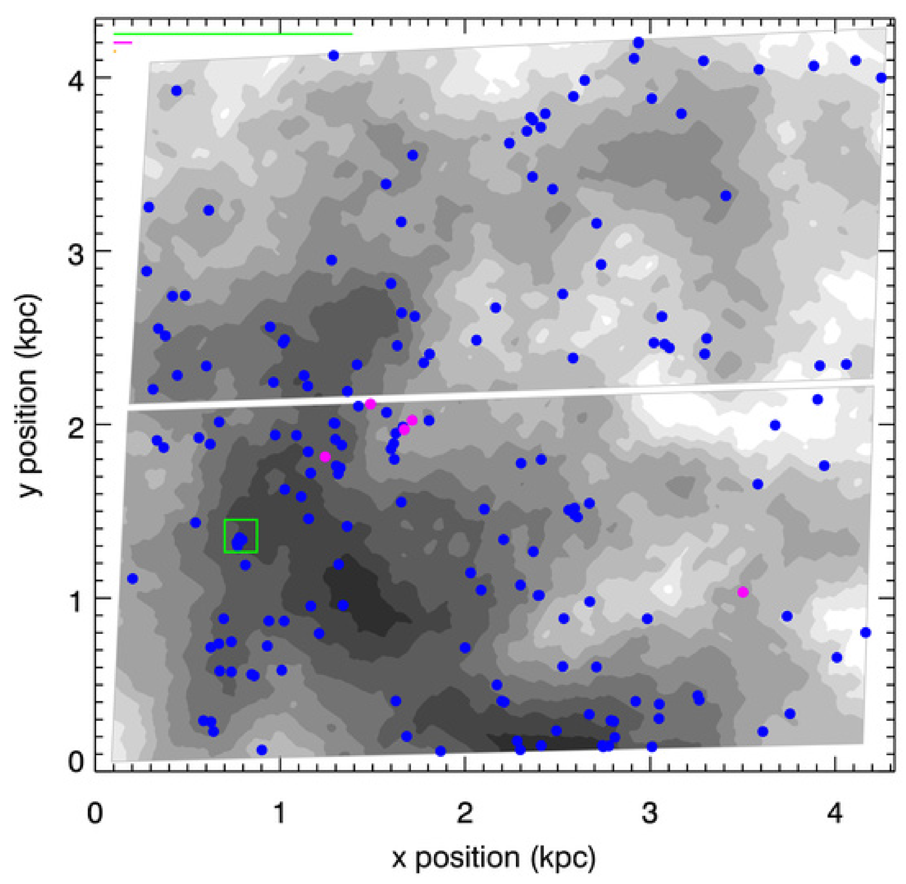


Figure 6: Distribution of main-sequence stars and HI gas. We show the HI contours from Elson et al. (2010) and the main-sequence stars are in blue. The HII region from Werk et al. (2010) is shown by the green box and the most luminous blue objects are shown in magenta.

Star formation in the outer disk accounts for 11-28% of the total star formation in NGC 2915

TOTAL STAR FORMATION

We determine the total star formation over the entire HI disk beyond its core (45-510 arcsec) to be 11% of the total star formation, assuming the derived SFL holds to the limits of the HI data and a Kroupa IMF. As we have shown, the IMF may vary from a Kroupa IMF in the centre to one deficient in high-mass stars in the outer disk. Assuming our preferred IMF, the star formation rate in the outer disk may be 28% of the total star formation in NGC 2915 (Bruzzese et al. 2014).

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